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PINK BOLLWORM INFESTATIONS AND RELATIONSHIPS TO COTTON YIELD IN ARIZONA

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ABSTRACT

T. J. Henneberry, L. A. Bariola, K. E. Fry, and D. L. Kittock. Pink Bollworm Infestations and Relationships to Cotton Yield in Arizona. U.S. Department of Agriculture, Agricultural Research Service, ARS W-49, 9 pp., 1977.

Seasonal average infestations of pink bollworm, *Pectinophora gossypiella* (Saunders), ranged from 15 to 31 percent with about 0.4 to 1.1 larvae per boll during three seasons and significantly reduced lint and seed yields in cotton, *Gossypium hirsutum* L. Highest reduction in yield occurred when infestations reached economic levels in late June and July during the peak boll production period. Yields were reduced less as high infestations developed later in the season. Percentages of damaged cottonseed were significantly correlated with larval infestations. Higher numbers of pink bollworm larvae were detected by using the holding method than by using the cut boll method.

KEYWORDS: pink bollworm, *Pectinophora gossypiella*, cotton, *Gossypium hirsutum* L., yield, boll infestation, seed damage

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Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
In Cooperation With
University of Arizona Agricultural Experiment Station

PINK BOLLWORM INFESTATIONS AND RELATIONSHIPS TO COTTON YIELD IN ARIZONA

By T. J. Henneberry, L. A. Bariola, K. E. Fry, and D. L. Kittock[1]

INTRODUCTION

Populations of pink bollworm, *Pectinophora gossypiella* (Saunders), have reached economic infestation levels in Arizona and Southern California since 1966, and cotton, *Gossypium* spp., has required insecticide spray applications each year to prevent yield losses. Most studies on the effects of infestations on cotton yield have been done with caged insects at extremely high, artificially induced population levels, which are seldom approached under cotton production conditions (Brazzel and Gaines, *1956*, *1957*; Lukefahr and Martin, *1963*).[2]

The present paper reports the results of studies conducted at Poston, Ariz., in 1973 and 1974, and Tempe, Ariz., in 1975, to determine the effect of pink bollworm populations on cotton yields under field conditions.

MATERIALS AND METHODS

1973 Experiment

A 10-hectare field, planted with 'Deltapine 16' (DPL 16) cotton in a plant-two-skip-one arrangement at Poston, was divided into 16 plots of 0.63 ha each. Eight of the fields were treated with scheduled insecticide applications as shown in table 1; eight of the plots remained untreated throughout the season.

Insecticide applications were made with a high-clearance ground sprayer in the equivalent of 468 liters water/ha with three nozzles per row at the first application and five nozzles per row at all subsequent applications.

Estimates of pink bollworm populations were made throughout the season by taking weekly samples of 150 green bolls from each of the 16 plots, July 10 through September 25. To compare sampling methods, 100 of these bolls, harvested July 10 to September 11, were examined for the presence of exit holes and opened, and the pink bollworm larvae were counted (table 2). The remaining 50 bolls were held in clear plastic sweater boxes. The number of pink bollworms was determined as described by Fye (*1976*). For the cut boll method, data are expressed as a mean number of pink bollworm larvae per 100 cotton bolls infested. For the holding method, data presented are larvae per 100 bolls. Four rows of cotton per plot, approximately 0.13 ha, were picked with a spindle picker for lint yield determinations on October 30 and again on December 5, 1973.

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[1] Henneberry and Bariola are entomologists, Fry is a plant physiologist, Western Cotton Research Laboratory, Phoenix, Ariz., and Kittock is an agronomist, Cotton Research Center, Phoenix.

[2] The year in italic, when it follows the author's name, refers to Literature Cited, p. 8.

TABLE 1.--*Mean number*[1] *of pink bollworm larvae and percent infested bolls from insecticide-treated*[2] *and untreated Deltapine 16 cotton plots at Poston, Ariz., 1973*

Sampling date	Larvae per 100 bolls: Insecticide treated[2]	Larvae per 100 bolls: Untreated	Percentage of bolls infested: Insecticide treated[2]	Percentage of bolls infested: Untreated
July 10	<1 a	1 a	<1 a	1 a
16	<1 a	1 a	<1 a	1 a
23	4 a	5 a	2 a	4 a
Aug. 1	6 a	7 a	3 a	3 a
8	4 b	8 a	1 a	1 a
13	6 a	9 a	<1 a	2 a
20	11 b	23 a	1 b	6 a
29	14 b	50 a	4 b	21 a
Sept. 3	14 b	56 a	10 b	26 a
11	23 b	132 a	4 b	32 a
17	58 b	168 a	28 b	54 a
25	76 b	198 a	32 b	64 a
Total	218 b	658 a	88 b	210 a
Seasonal mean	18 b	55 a	7 b	18 a

[1] Means of 8 replications followed by the same letter within a category in the same row are not significantly different at the 5-percent level of significance, according to Duncan's Multiple Range Test.

[2] Plots treated on July 5, 10, 17, and 24 with 420 grams active ingredient/ha chlordimeform [*N*-(4-chloro-*o*-tolyl)-*N*,*N*-dimethylformamidine]; on July 31, Aug. 7, and 14 with 420 gai/ha chlordimeform plus 489 gai/ha monocrotophos [dimethyl phosphate ester with (E)-3-hydroxy-*N*-methylcrotonamide]; on Aug. 21, 28, and Sept. 11 with 711 gai/ha monocrotophos; and Sept. 18 with 264 and 132 gai/ha 6-3 methyl/ethyl parathion [methyl parathion = *O*,*O*-dimethyl *O*-(*p*-nitrophenyl) phosphorothioate; ethyl parathion = *O*,*O*-diethyl *O*-(*p*-nitrophenyl) phosphorothioate].

TABLE 2.--*Mean number*[1] *of pink bollworms per 100 cracked and incubated bolls from Deltapine 16 cotton plots, Poston, Ariz., 1973*

Sampling date	Larvae per 100 bolls				Correlation coefficients ("r")
	Cracked		Incubated		
July 10	<1	a	2	a	0.30
16	1	b	3	a	.09
23	3	a	4	a	.43
Aug. 1	3	a	7	a	.40
8	1	b	3	a	.23
13	2	b	5	a	.35
20	4	b	13	a	.93**
29	18	b	31	a	.87**
Sept. 3	24	b	57	a	.71**
11	22	b	44	a	.99**
Total per 1,000 bolls	79	b	159	a	.96**
Seasonal mean	7.9	b	15.9	a	

[1] Means of 12 replications followed by the same letter in a row are not significantly different at the 5-percent level of significance, according to Duncan's Multiple Range Test.

**Statistically significant, 1-percent probability level.

1974 Experiment

A 16.2-ha field of DPL 16 cotton at Poston was divided into four equal-sized blocks. These blocks were treated with insecticides according to the schedule shown in table 3. Eight 0.15-ha plots remained untreated during the season.

Fifty green bolls were taken weekly, June 22 to September 6, from each of five sampling sites in each treated block. One hundred bolls per week were collected from each of the untreated plots. Estimates of pink bollworm populations in the bolls were made by the holding method as previously described.

Four rows of cotton per plot were picked November 4 with a spindle picker for lint yield determinations in the untreated control plots. In the treated plots, cotton was handpicked from 18.3 m of row in each block.

TABLE 3.--*Mean number*[1] *of pink bollworm larvae from 4 insecticide-treated and 8 control Deltapine 16 cotton plots, Poston, Ariz., 1974*

Sampling date	Larvae per 100 bolls: Insecticide treated[2]	Larvae per 100 bolls: Untreated
June 22	19 a	20 a
July 15	19 a	37 a
23	6 b	93 a
29	7 b	110 a
Aug. 5	18 b	172 a
12	8 b	90 a
19	4 b	127 a
28	2 b	15 a
Sept. 6	2 b	29 a
Total per 900 bolls	85 b	693 a
Seasonal mean	9.4 b	77.0 a

[1] Means of 4 insecticide-treated plots and 8 untreated plots, 100 to 250 bolls per sampling date from each plot. Means within a row followed by the same letter are not significantly different at the 5-percent level of significance, according to Duncan's Multiple Range Test.

[2] Plots treated on July 9; Aug. 2, 7, 10, 15, 16, 20, 24, 29; and Sept. 2 with 282 grams active ingredient/ha chlordimeform plus 711 gai/ha monocrotophos, 561 gai/ha methyl parathion, 842 gai/ha malathion [*O*,*O*-dimethyl phosphorodithioate of diethyl mercaptosuccinate], 561 gai/ha dicrotophos [dimethyl phosphate ester of (*E*)-3-hydroxy-*N*,*N*-dimethylcrotonamide], 1,122 gai/ha dicrotophos, 711 gai/ha monocrotophos, 711 gai/ha monocrotophos, 561 gai/ha methyl parathion, 711 gai/ha monocrotophos, and 842 gai/ha each ultra low volume malathion, respectively, on consecutive treatment dates.

1975 Experiment

Twenty plots (about 0.1 ha) of DPL 16 cotton were grown at the Arizona State University Farm Laboratory, Tempe. Plots were arranged in four randomized blocks. Treatments consisted of an unsprayed control and four different insecticide spray schedules designed to regulate pink bollworm boll infestation levels at less than 5, 10, 20, and 40 percent. Weekly samples of 25 green bolls were picked from each plot from July 5 to October 15. Green bolls were examined for exit holes and opened immediately, and the number of larvae were counted. Treatment timing was based on percentages of infested bolls.

Insecticides were applied with a high-clearance ground sprayer having three nozzles per row. Materials used, rates, and dates of applications are shown in table 4.

On December 9, 1975, four rows (about 0.01 ha) in each plot were picked with a spindle picker to estimate lint yields. Cottonseed was X-rayed by the method of Wilson and Wilson (*1975*) to determine percentages of damaged seed.

RESULTS

1973 Experiment

Both sampling methods indicated that pink bollworm infestations were low in all plots until mid-August (table 1). In the untreated plots, there were 0.5 larvae per boll and 21 percent boll infestation on August 29. Pink bollworm populations increased rapidly thereafter in the untreated plots, reaching about 2.0 larvae per boll and 64 percent infested bolls on September 25. Populations also increased in treated plots, reaching about 0.8 larvae per boll and 32 percent of the bolls infested on the same date.

Lint yield was reduced 18 percent in untreated cotton plots. Mean yield was 1,823 kg/ha in the eight plots that received 11 insecticide applications and 1,490 kg/ha in the eight untreated plots.

More pink bollworm larvae were detected in bolls by the holding method of Fye (*1976*) than by the cut boll method (table 2). Our results agree with those of Fye and indicate that cut-boll sampling methods, for decisionmaking in initiating control measures, may underestimate pink bollworm populations. The two methods were poorly related, as indicated by the correlation coefficients, until infestations approached economic levels (table 2).

1974 Experiment

In 1974, pink bollworm populations in untreated plots reached levels of 0.9 larvae per boll by July 23 (table 3). In 1973, this level of infestation had not been reached until after September 3. Lint yields were reduced 47 percent in untreated plots. Mean lint yield from eight untreated cotton plots was 1,167 kg/ha and from treated plots was 2,195 kg/ha. Cotton boll set typically begins in early June and peaks in early to mid-July (Kimball et al., *1976*). Thus, early infestations of pink bollworm reduced lint yield dramatically as shown by our results.

1975 Experiment

Pink bollworm larval infestations in the untreated check plots reached 0.61 larvae per boll with 20 percent of the bolls infested by August 30. Peak populations were reached October 6 with 84 percent of the bolls infested and 3.8 larvae per boll (tables 4 and 5). Weekly insecticide applications kept larval populations below 0.20 larvae per boll with less than 10 percent of the bolls infested until September 24. Other spray schedules resulted in average seasonal percent infestation levels of 15, 24, and 31 percent of bolls infested with 0.41, TABLE 4.--*Mean number*[1] *of pink bollworm larvae from untreated and insecticide-treated cotton plots, Arizona State University Farm Laboratory, Tempe, Ariz., 1975*

Percent infestation[2]		Larvae per 100 bolls for the following sampling dates--														
		July	August					September						October		Seasonal mean
Planned	Observed	24	1	8	15	22	30	5	10	13	19	24	27	6	15	
(Untreated)	28	6	11	4 ab	15 a	21	61	72 a	70 abc	70	83 b	147 a	185 a	380 a	245 a	97 ab
5	[3]11	4	4	1 b	7 bc	11	19	14 b	22 c	15	16 c	14 b	29 c	107 b	98 b	26 c
10	[4]15	4	10	12 a	7 bc	18	28	71 a	24 bc	41	39 c	58 b	67 bc	101 b	99 b	41 c
20	[4]24	4	5	1 b	4 c	31	37	47 ab	77 ab	56	70 b	42 b	108 b	410 a	293 a	86 b
40	[5]31	8	7	4 ab	14 ab	22	68	47 ab	80 a	51	155 a	185 a	160 a	405 a	293 a	111 a

[1] Means of 4 replications; 25 bolls per replication in each sampling date; means within a column not followed by a letter or the same letter are significantly different at the 5-percent probability level, according to Duncan's Multiple Range Test.

[2] Seasonal mean.

[3] Plot treated July 15 and 23 with 1,121 grams active ingredient/ha monocrotophos; July 30 with 560 gai/ha azinphosmethyl [*O,O*-dimethyl *S*-[(4-oxo,1,2,3-benzotriazin-3(4*H*)-yl)-methyl] phosphorodithioate]; and Aug. 6, 13, 20, 27, Sept. 3, 8, 12, 22, 26, Oct. 1, 6, 11 with 560 gai/ha azinphosmethyl plus 280 gai/ha chlordimeform.

[4] Plots treated Aug. 27, Sept. 3, 8, 12, 22, 26, Oct. 1, 6, 11 with 560 gai/ha azinphosmethyl plus 280 gai/ha chlordimeform.

[5] Plots treated Sept. 22, 26, Oct. 1, 6, 11 with 560 gai/ha azinphosmethyl plus 280 gai/ha chlordimeform.

TABLE 5.--*Percent bolls*[1] *infested in untreated and insecticide-treated cotton plots at Arizona State University Farm Laboratory, Tempe, Ariz., 1975*

Percent infestation[2]		Percent bolls infested for the following sampling dates--													
		July	August					September						October	
Planned	Observed[3]	24	1	8	15	22	30	5	10	13	19	24	27	6	15
(Untreated)	28	2	8	4	13 a	14	20 a	21 a	20 a	17 a	22 bc	46 b	60 a	84 a	69 a
5	[4]11	4	4	2	7 abc	8	2 b	2 b	2 b	1 b	5 d	8 d	16 c	50 b	36 b
10	[4]15	3	9	8	6 bc	14	15 a	23 a	6 b	18 a	10 cd	14 cd	24 c	37 b	29 b
20	[4]24	4	5	1	4 c	19	17 a	17 ab	9 b	14 ab	25 b	27 c	42 b	82 a	68 a
40	[4]31	6	6	5	12 ab	14	23 a	25 a	12 cd	17 a	51 a	66 a	41 b	76 a	74 a

[1] Mean percentage of bolls infested, 4 replications, 25 bolls per plot, means within a column not followed by a letter or the same letter are significantly different at the 5-percent level of significance, according to Duncan's Multiple Range Test.

[2] Seasonal mean.

[3] Observed = Average seasonal percentage of infestation per plot, 4 replications, 14 sampling dates.

[4] See table 4 for insecticide spray schedules.

0.86, and 1.1 larvae per boll, respectively. All plots that received five to nine insecticide applications reached peak boll infestation levels much higher than 20 percent with one or more larvae per boll. When insecticide applications were delayed until late August and September, after infestations had become well established, treatments were relatively ineffective. Lint yields were significantly lower in the untreated plots and the plots treated 5 to 9 times than in the plots treated 15 times (table 6).

Approximately 19 percent of the seed was damaged by pink bollworm larvae in the untreated cotton plots with 9, 12, 17, and 22 percent seed damage in plots treated 15, 9, 9, and 5 times, respectively, with insecticide. Total larvae for the season in boll samples were significantly correlated ("r" = 0.73**) with percent damaged seed identified by the X-ray technique of Wilson and Wilson (*1975*).

TABLE 6.--*Mean*[1] *cotton lint yield and percentages of damaged seed in untreated and insecticide-treated Deltapine 16 cotton plots, Arizona State University Farm Laboratory, Tempe, Ariz., 1975*[2]

Percent infestation[3]			Damaged
Planned	Observed	Lint yield	seed
		Kg/ha	*Percent*
(Untreated)	28	596 b	19 a
5	11	1,058 a	9 c
10	15	699 b	12 bc
20	24	776 b	17 ab
40	31	674 b	22 a

[1] Means of 4 replications wthin a column followed by the same letter are not significantly different at the 5-percent level of significance, according to Duncan's Multiple Range Test.

[2] See table 4 for insecticide spray schedules, materials, and rates.

[3] Seasonal mean.

DISCUSSION

Significant reductions in cotton lint yield occurred in our plots at much lower pink bollworm infestation levels than those reported by other authors. For example, Brazzel and Gaines (*1956*) reported from field cage tests that 6.4 and 9.6 larvae per boll resulted in most of the loss in value of cotton from reduced fiber quality and that 12.9 larvae per boll reduced yield more than quality. Pink bollworm infestation levels up to approximately 50 percent infested bolls, and less than two larvae per infested boll were subsequently reported to cause relatively small decreases in the value of cotton produced (Brazzel and Gaines *1957*). Infestations in the field rarely reach these levels.

More realistic pink bollworm population levels of about 22, 36, and 60 percent boll infestation with 0.34, 0.93, and 1.89 larvae per boll were studied by Lukefahr and Martin (*1963*). These authors observed that cotton crop values were reduced 34 percent when seasonal boll infestations averaged at least 60 percent, with the loss equally distributed between reductions in yield and quality. Kittock and Pinkas (*1971*) found relatively minor differences between cotton fiber properties from pink bollworm-infested and noninfested bolls. They suggested that the reductions in quality were caused by invasion of boll-rot organisms rather than by pink bollworm damage.

Watson and Fullerton (*1969*) were unable to detect yield differences in plots sprayed 10, 15, or 19 times; however, boll infestations were usually less than 5 percent in all sprayed plots. Untreated plots averaged 38 percent infestation for the season, and yields of seed cotton were reduced 24 percent in 1967. In 1968, yields were not significantly different in plots with average larval infestation levels of 42, 15, 15, 21, and 25 percent. They concluded that control measures are unwarranted before at least 20 percent of the green bolls become infested. A more critical factor, however, appears to be whether infestation reaches a high level during the peak boll production period.

In our tests, for example, cotton lint yields were significantly lower and pink bollworm infestations were significantly higher in each of 3 years in untreated or lightly treated plots than in those heavily treated with insecticides. The highest yield loss, 53 percent, occurred in 1974, but a yield reduction of 18 percent occurred in 1973, and reductions of 27 to 44 percent occurred in 1975. The highest numbers of larvae and percent bolls infested occurred earlier in 1974 than in 1973 or 1975. Higher yield losses are attributed to the higher populations of pink bollworms during initiation and peak development (early June to early July) of cotton bolls.

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